ANTHRAX

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The earliest reference to anthrax is found in the "Fifth Plague" in the Book of Genesis; all of the Egyptians'cattle died of a disease that, from the description, must have been anthrax. The early literature of the Hindus, Greeks, and Romans contains descriptions of both animal and human anthrax. In the 17th Century, a pandemic referred to as the "Black Bane" swept through Europe, killing 60,000 human beings and many animals. Major epidemics were reported from many European countries over the next century; subsequently, the disease has been reported from almost every country in the world. Glassman[1] estimated that the annual worldwide incidence of human anthrax was 20,000-100,000 cases.

Anthrax was introduced into the United States through the Mississippi Delta. The earliest cases among animals were reported from Louisiana in the early 1700's. By the 1800's, epizootics were being reported mainly from the South and the Northeast. The first human cases were reported in 1824 among cattle tenders in Kentucky; their cutaneous lesions developed presumably from contact with diseased animals. Cases have now been reported from almost every state in the country.

The organism was first seen microscopically by Delafond in 1838. In the 1870's Pasteur used *Bacillus anthracis* in some of his earliest studies on the germ theory of disease. In 1876**,** Koch used *B. anthracis* as his model in describing his postulates. In 1881 Pasteur successfully field-tested an animal anthrax vaccine, a momentous advancement in the field of animal husbandry.

In the late 1800's**,** woolsorter's disease in England and rag picker's disease in Germany, both synonyms of inhalation anthrax, were serious occupational hazards for persons working with raw imported animal fibers. In England, disinfection with formaldehyde brought this problem under control. In the 1950's, human anthrax vaccines were developed and successfully tested in both the United States and Great Britain,[2] the use of which has reduced the incidence of anthrax among both industrial and laboratory workers.

The clinical spectrum of disease includes cutaneous, inhalation, and gastrointestinal anthrax, the names reflecting the route by which organisms enter the body. Anthrax meningitis or septicemia can complicate any of the above primary forms. The earlier literature describes lesions of the nasal and oral cavities, pharyngeal region, the trachea and the bronchi, which in essence represent the site of deposition of spores, which subsequently germinate and multiply *in situ.*

In the United States, the number of cases reported each year has gradually but steadily decreased since 1916 except for several industrially related peaks **(**FIGURE 1). The peaks in 1917 and 1941 were the result of increased industrial exposure to imported contaminated animal fibers in the textile industry. The peak in 1924 resulted from workers' handling contaminated hides obtained from cattle that died in the large epizootic in the Southeast that year. In the 10-year period 1916-1925 an average of 127 cases a year were reported, whereas in 1961-1969, seven cases per year were reported. The number of deaths has also proportionately decreased, with only nine reported in 1956-1968. This decreased incidence is the result of utilization of vaccine, improved working condition, and decreased exposure to imported contaminated animal products.

Human anthrax in the United States may be classified as due either to industrial or to agricultural exposure, with the former accounting for approximately 80% of reported cases (FIGURE 2). In previous years, wool and hides have accounted for the majority of industrially related cases, whereas since 1955, 64% of the 171 cases reported resulted from contact with imported goat hair (TABLE 1). Within the involved industries, cases have been reported most frequently from among those individuals who have had the closest contact with imported contaminated raw materials. There are no age and sex characteristics specific for anthrax.

Cutaneous anthrax results when spores are deposited beneath the surface of the skin, being carried through on penetrating hair fibers or gaining entrance through preexisting abrasions. *Bacillus anthracis* spores have been readily recovered from the intact skin or even from the external nares and the pharynx unassociated with disease.[3]

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Cutaneous lesions develop primarily on the exposed parts of the body (Figure 3). There have been no confirmed reports of human-to-human transmission; however, cases have occurred among wives and children of industrial workers; the source of infection was reportedly contaminated work clothes. Ninety-five percent of all anthrax cases reported in the United States are cutaneous. A typical lesion develops after an incubation period of one to seven days (usually two to five days) as a painless papule and progresses into a vesicle or a ring of vesicles, which coalesce. The vesicle enlarges, ruptures, and exudes a clear fluid, from which *B. anthracis* can easily be recovered. Beneath the vesicular tissue a black depressed eschar is developing, which, over the next several days, enlarges to cover the base of the ulcer. There may be some nonpitting edema and erythema surrounding the lesion, and occasionally lymphangitis and possibly lymphadenopathy. Pruritus is a frequent complaint, but pain is rare. Systemically, there may be low-grade fever and malaise. The eschar dries and separates, leaving a scar. Therapy with a broad-spectrum antibiotic, such as penicillin, will prevent recovery of the organism from the lesion, usually within 24 hours, and will bring about a rapid clinical response; however, the lesion will evolve through all stages as described, in spite of antibiotic therapy.

TABLE 1
SOURCE OF INFECTION, 211 CASES OF ANTHRAX, 1955-1969

Industrial		Agricultural	
Goat Hair	106	Animals	30
Wool	33	Vaccine (animals)	2
Goat Skins	15	Unknown	8
Bone	3		___
Meat	3		
Unknown	11	Total	40
Total	171		

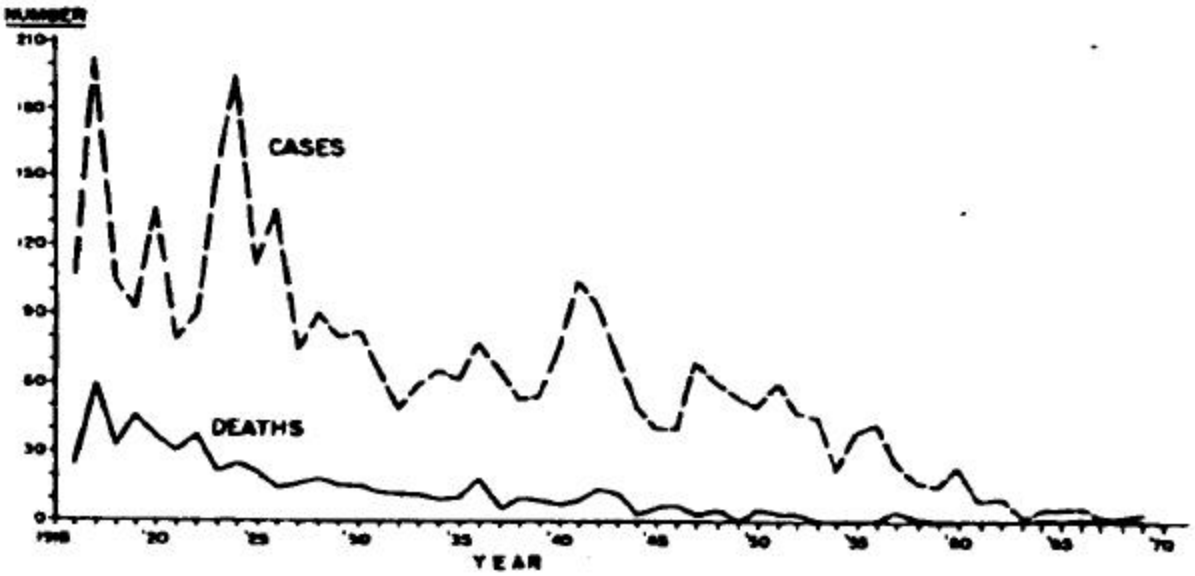

FIGURE 1. Anthrax in man in the United States, 1916-1969

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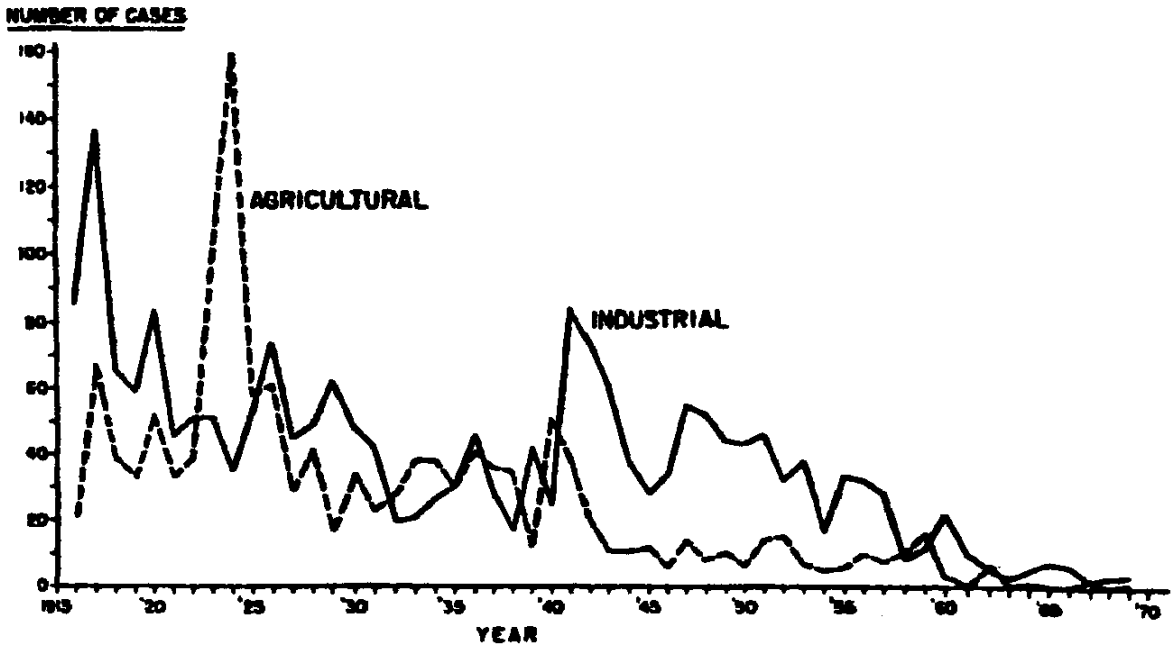

FIGURE 2. Industrial and agricultural anthrax in man in the United States, 1916-1969

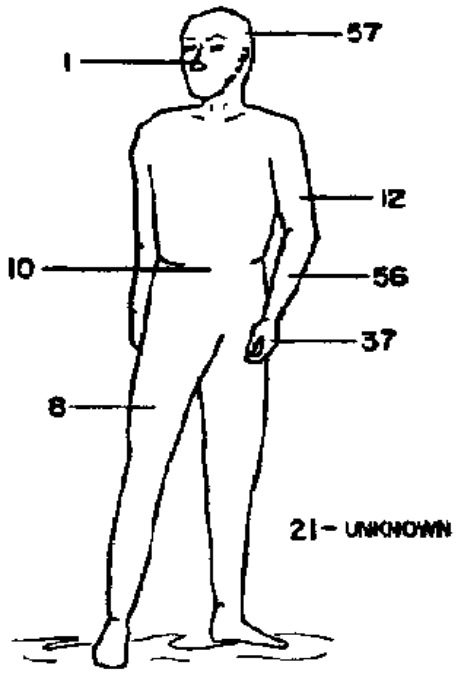

FIGURE 3. Site of anthrax infection, 1955-1969; 202 cutaneous cases

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Without antibiotic therapy, mortality ranges up to 20 percent. With prompt therapy there should be no deaths. Differential diagnosis includes other skin infections such as staphylococcal infection, tularemia, plague, contagious pustular dermatitis (orf), and "milker's nodule." The spectrum of clinical disease and epidemiology can be shown in a review of several unusual cases. The first is that of a 22-year-old grocery clerk who developed a "boil" on the outer surface of his left forearm. On admission to the Philadelphia Contagious Disease Hospital on the sixth day of disease, he had a typical anthrax lesion. He made an uneventful recovery after treatment with penicillin. A careful epidemiologic investigation was conducted, and all possible sources of *B. anthracis* at his place of employment or within his home were excluded. His mother worked in a goat-hair spinning mill; however, this did not appear to be a likely source of his infection. Further inquiry revealed that the patient had purchased a new wool coat approximately 15 days before the lesion developed. He had worn the coat five days before and on the day that he first noted the boil. The coat was brought into the laboratory and divided into its three component parts, the outer woolen layer, the inner lining, and the interlining. Each layer of the coat was cut into fragments, which were cultured separately. *Bacillus anthracis* was isolated from two separate samples of the outer woolen part of the garment, but from no other part of the coat. On careful questioning, the patient and his physician both stated that there had been no discharge from the lesion until four days after onset, which was also four days after be had last worn the coat. Unfortunately, similar coats from the same lot were not available for examination.

Another unusual case is that of a 62-year-old longshoreman who developed a pruritic papule on his right cheek while at work on a Philadelphia pier unloading wool imported from Syria. Within 12 hours he noted swelling around the lesion and later experienced a shaking chill. On the following day the lesion exuded a watery discharge, and by the third day the lesion extended around the eye, involving both lids, with so much edema that his right eye was swollen shut. The edema extended to the left side of his face onto his forehead and scalp, and down his neck. He had several additional chills. On the fifth day of his disease, the diagnosis was confirmed with positive cultures from both the lesion and blood. By the eighth day of disease, a typical black eschar involved both the upper and lower lid of the right eye; the erythema and edema had regressed. By the twenty-first day the edema had disappeared and the eschar was beginning to separate at the edges. The extensive nature of this lesion may have been related to inoculum size and the looseness of the subcutaneous tissue surrounding the eye, allowing the unimpeded spread of the locally produced toxin. Epidemiologic investigation at the pier where the patient worked revealed a broken bale of wool that he had handled while unloading the ship. Samples from this bale were positive for *B. anthracis.*

Rarely, lesions have been reported in the United States in which the cutaneous reaction is that of multiple blebs and massive edema, historically referred to as malignant edema. Very rarely is a patient seen with two simultaneous lesions that represent either coprimary or possible spread from a primary site to a secondary site. One such case has been reported in the United States since 1955. Inhalation anthrax, which accounts for less than five percent of anthrax cases seen in the United States, results from the inhalation of *B. anthracis*-bearing particles less than 5μ in diameter that are carried to the terminal alveoli. There they are transported across the alveolar membrane in macrophages and deposited in the regional mediastinal lymph nodes, where they may germinate and subsequently multiply and produce anthrax toxin. Toxin disseminated throughout the body causes symptoms of toxemia, usually resulting is death. The role of the lymphatics in the distribution of toxin and organisms have been well shown in the monkey.[4]

The clinical course after an incubation period of one to five days is that of a nonspecific disease with mild fever, myalgia, some malaise, and occasionally a sensation of precordial oppression. "Flu" has been an early diagnosis. However, within two to four days there is a sudden intensification of these symptoms, with dyspnea, cyanosis, profuse diaphoresis, shock, and rapid collapse, with death within hours or one or two days as a result of generalized toxemia.[5]

Should the diagnosis be considered, therapy with large doses of intravenous penicillin and intramuscular streptomycin is recommended; if available, use of an antitoxin preparation would be further recommended. Mortality rates approach 100 percent.

Of the nine cases reported in the United States since 1955, five occurred during the epidemic at a goat-hair processing mill in New Hampshire in 1957.[6] All of these cases could be related to contact with the dustiest part of the mill. One of the other four patients with inhalation anthrax had occupational exposure in a microbiology laboratory, and another, a secretary in a goat-hair mill, was briefly exposed to aerosols in the dustiest part of the mill while looking for a foreman. The other two patients were not working within a contaminated environment and had only chance exposure, one as he walked by the open door of the unloading platform of a tannery that processed imported goat skins, and the other as he

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worked downwind from an open window of a goat-hair processing mill.[7]

Human intestinal anthrax, with a mortality rate of 50-100%, usually follows the ingestion of raw or inadequately cooked contaminated meat obtained from an animal slaughtered because of illness or found dead. This form of the disease has never been reported in the United States, but two recent papers from Thailand reported two separate outbreaks of two cases each, with the diagnoses proven at autopsy, and they can serve to summarize this form of the disease.[8,9] The four patients ranged in age from 14 to 60 years. Three to five days after eating contaminated meat, the patients had symptoms consisting of generalized abdominal pain, fever, vomiting, and diarrhea. On admission to the hospital, they were restless, dehydrated, and hyperpneic, with abdominal distension, generalized or localized tenderness, and decreased bowel sounds. Paracentesis revealed up to three liters of acetic fluid that was either straw-colored or serosanguinous. In some instances the diagnosis of food poisoning or typhoid fever was made, and patients were placed on penicillin and streptomycin therapy. However, irreversible shock developed. The patients became stuporous, with increased restlessness, abdominal distension, and pain; they died anywhere from five hours to three days after admission. At autopsy, the notable lesions were those of hemorrhagic inflammation of the intestinal mucosa with a 12-15 cm ulcerous lesion in the terminal ileum or cecum with surrounding edema and hemorrhagic, enlarged regional lymph nodes. Other organs showed varying degrees of hemorrhagic diathesis; in one patient there was a massive subarachnoid hemorrhage.

In conclusion, this disease of antiquity has an important place in the evolution of the science of bacteriology. Historically, it was truly an epidemic disease with high mortality. Today its past reputation persists; however, the incidence in the United States has decreased to less than five cases annually. The most common form is the almost benign cutaneous lesion. However, more severe cutaneous lesions or inhalation cases may occur. A degree of suspicion is necessary in making the diagnosis of anthrax, especially if a potential source of contamination is present.

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